# Scientific Intelligence Officers' Operational Notes

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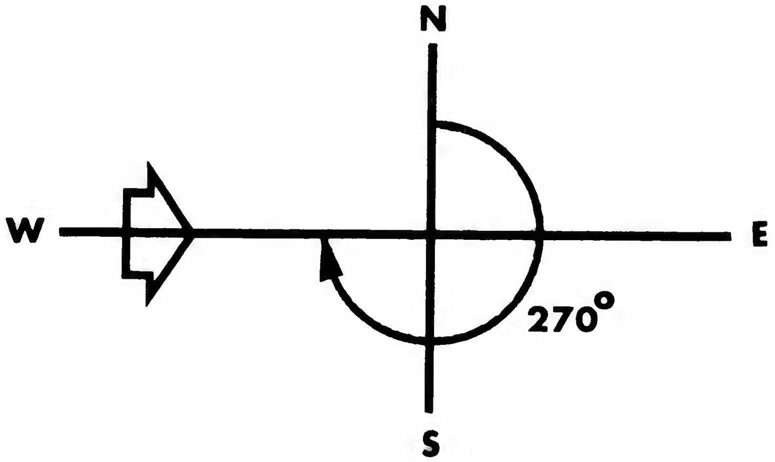
# Mechanism of fallout

## Definitions

Wind direction is the direction from which the wind blows, and is given in degrees measured clockwise from north. E.g. A 270° wind blows from the west.




Wind speed is actually measured in knots, but the unit of speed usually used by the SIO is the mile per hour (mph).

1 knot = 1 nautical mile per hour
1 nautical mile = 6080 feet
1 knot = 1.15 mph = $1\frac{1}{7}$ mph (approx.)

N.B. In meteorological forecasts received by the SIO wind speeds will normally be in mph. If a forecast is mistakenly transmitted in knots, then the SIO should transform, using the above relationship. In approximate calculations the difference between a knot and a mile per hour may be neglected.

Winds changing direction with time

(a) If a wind turns clockwise it is said to be veering.
(b) If a wind turns anticlockwise it is said to be backing.

A forecast concerns meteorological data only.

A prediction indicates where fallout may go. It is based on a forecast and on bomb data.

A micron ($\mu$) is one millionth of a metre.
1000 microns = 1 millimetre.

Useful wind data

The following data applies to the 0-60,000, 0-70,000 and 0-80,000 feet mean vector winds.

(a) Variation with speed

Probabilities of occurrence of speeds (all directions)

| Speed range (mph) | 0-7 | 7-18 | 18-35 | 35+ |
|---|---|---|---|---|
| Percentage probability | 4 | 17 | 36 | 43 |

(b) Variation with direction

Probabilities of directions occurring in 60° sectors (all speeds)

| Wind direction (degrees) | 0-60 | 60-120 | 120-180 | 180-240 | 240-300 | 300-360 |
|---|---|---|---|---|---|---|
| Percentage probability | 7 | 4 | 5 | 17 | 41 | 26 |

(c) Angular wind shear

This is defined for the present purpose as the angle which includes the directions of all the mean vector winds up to the 0-90,000 feet one, excluding the surface wind. This angle will give a very crude idea of the amount of lateral spreading which might occur in the fallout pattern.

Percentage probability of occurrence of angular shear

| Angular shear (degrees) | Mean vector wind speed (mph) | | | | Total |
|---|---|---|---|---|---|
| | 0 - 7 | 7 - 18 | 18 - 35 | 35 + | |
| 0-15 | 0 | $2\frac{1}{2}$ | $9\frac{1}{2}$ | 21 | 33 |
| 15-30 | $\frac{1}{2}$ | $3\frac{1}{2}$ | 13 | 11 | 28 |
| 30-75 | $\frac{1}{2}$ | 7 | $10\frac{1}{2}$ | 10 | 28 |
| 75 + | 3 | 4 | 3 | 1 | 11 |
| Total | 4 | 17 | 36 | 43 | 100 |

Mode of decay

Any single radioisotope decays according to an exponential law $N_t = N_o e^{-\lambda t}$, where $N_o$ and $N_t$ are the number of atoms present initially and at time t. $\lambda$ is a decay constant and can be shown to equal 0.693/T, where T is the half-life of the isotope, i.e. if the activity was originally, say, 8 units, then it will have decayed to 4 units after time T, 2 units after time 2T, 1 unit after time 3T, etc.

Fission products from a nuclear explosion are a mixture of over 200 different radioisotopes with half-lives varying from fractions of a second to many thousands of years. Many of them, moreover, are not produced immediately but are the result of the decay of other nuclides. In addition, the mixture may contain some activity due to neutron activation of the bomb components resulting in the formation of neptunium 239. The decay of this mixture is not exponential and thus cannot be described by a half-life. From nuclear weapons trials it has been found for the first 100 days to follow approximately the $t^{-1.2}$ power law, i.e. $R_t = R_1 t^{-1.2}$, where $R_1$ and $R_t$ are the dose-rates at 1 hour and t hours after detonation

Factors upsetting normal decay

Probable causes of deviation from the $t^{-1.2}$ decay law are:-

(a) fractionation
(b) neutron activation of soil elements
(c) weathering
(d) rigging or salting of weapons

Fractionation

This is a complex condensation process and is by no means fully understood. Its effect is to give the close-in FO a different composition and hence a different decay from the more distant FO downwind. For example, close-in FO has been found to contain less strontium 90.

Two likely causes of fractionation are:-

(a) as the fireball cools the nuclides with the higher boiling points condense first and do so while the larger particles forming the close-in FO are still present in the cloud. The more volatile nuclides condense later when the larger particles have left the cloud and so tend to contaminate the lighter particles which are carried further downwind.

(b) certain of the fission products are inherently gaseous (e.g. krypton) or have gaseous precursors (e.g. caesium 137). The heavier particles fall out before these nuclides have decayed to non-gaseous daughters capable of condensing on to them. Close-in FO is therefore deficient in these elements. Conversely the smaller particles forming the more distant FO are enriched in them.

## Neutron activation of soil elements

For FO to be produced on a substantial scale, the explosion must take place on or near the ground, in which case the radioactivity from the fission products and the bomb materials is supplemented by neutron-induced activity from certain elements in the soil. For the 50% fission weapon this extra activity is small but may be appreciable for the so-called "clean" bomb where possibly only 10% of the total energy is from fission. The number of spare neutrons is doubled and the fission product activity reduced by a factor of 5. Under these circumstances induced activity can become a substantial proportion of the whole. Calculations made on typical UK soils show that the elements most likely to contribute to this activity are sodium and manganese. Under neutron activation these form the gamma emitters sodium 24 and manganese 56. Sodium and manganese are present in soils in varying amounts according to the locality. Sodium, for example, is more abundant in the rock-salt areas of Cheshire and in regions of igneous rock formation. Manganese is fairly uniformly distributed but usually only in small amounts.

If a large quantity of a particular isotope such as sodium 24 is added to a fission product mixture obeying the $t^{-1.2}$ law, the effect is to increase the dose-rate by an amount varying with time. It can be shown that the isotope exerts its maximum proportional effect at a time equal to 1.73 times its half-life. For sodium 24 and manganese 56 the details are:-

| Isotope | Half-life (hours) | Time of maximum proportional effect (hours) |
|---|---|---|
| Na24 | 15 | 26 |
| Mn56 | $2\frac{1}{2}$ | $4\frac{1}{2}$ |

For a 10% fission bomb the sodium 24 contribution to the total DR at H + 26 hours could be over 80% for some bomb designs and soil constitutions; the manganese 56 contribution at H + $4\frac{1}{2}$ hours could be over 10%.

# Notes on BW and CW

## General

Toxicological warfare can consist either of a tactical attack with chemical weapons producing an immediate incapacitating effect, or of a strategic attack with biological weapons which have a delayed effect.

The new Civilian Respirator (C7), with pneumatic tube face fitting which is comfortable for long periods of wearing, affords excellent protection against BW and CW attacks.

## BW

CD Pamphlet No. 7 on BW is still of general use for training purposes but the emphasis now is more on the airborne inhalation hazard over large parts of the UK rather than on attack against specific targets: there are serious disadvantages in the use of epidemic agents.

Clandestine methods of attack cannot be ignored.

Communal protection depends upon good medical and sanitary services: these may be overlooked or may break down in a nuclear war thus increasing the temptation of an enemy to use BW.

Attacks on animals and crops are possible. SIOs may be asked to have samples taken but detection, identification and counter-measures are the responsibility of the agricultural authorities.

In attacks on populations, since the airborne hazard is the main one, only agents of high infectivity and high virulence, (i.e. a small number of organisms required to produce infection and cause severe illness), combined with viability for many hours in the atmosphere, are likely to prove effective.

## Some representative pathogenic micro-organisms

| | | |
|---|---|---|
| Bacterial | Anthrax | (lethal, very persistent spores but relatively low infectivity) |
| | Brucellosis | (incapacitating) |
| | Tularaemia | (incapacitating or lethal) |
| | * Rickettsial | Q fever (like typhus) |
| | * Viruses | Encephalomyelitis (brain fever) |
| | | Smallpox (epidemic) |

## Detection and sampling

Identification of bacterial and rickettsial agents at a central laboratory is possible within one to two days of collecting a sample. Identification of virus agents would probably require a few hours more.

Personal protection

Respirators and discardible covers for head and body may be used. Extreme personal cleanliness is necessary. Total dosage can be reduced very considerably in a closed room in a house by sealing window cracks and door gaps before the arrival of contamination and ventilating the room fully as soon as it has passed.

Decontamination

Where appropriate the following measures may be taken:-

(a) weathering for a few days will destroy most bacterial agents other than anthrax spores
(b) use of bleach solution
(c) scattering petrol and firing it on open contaminated ground.

CW

Pamphlet No. 1, Basic Chemical Warfare is now obsolescent. Manual for SIOs (TROs) Part 2 (1960) is still of value until a new manual can be written on equipment now in final stages of development. The main defences against CW are respirators, shelter and rapid detection. The duties of SIOs are defined in pp.28-32 of the above manual.

The characteristics of an ideal CW agent are toxicity, cheapness, ease of dispersion, stability as an aerosol or droplet cloud in air, difficulty of detection, a hazard on skin and clothing as well as being an inhalation hazard.

Mustard gas and anticholinesterase agents (persistent and non-persistent nerve gases) are the CW agents most likely to be encountered in a tactical battle.

Detection of CW agents in gaseous or liquid form

(a) observation of immediate effects on insects, birds, animals and people in the vicinity
(b) a new Kit (Residual) Vapour Detector is under development
(c) a new type of detector paper is being developed for the detection of aerosol and liquid droplets.

Decontamination of skin, clothing and equipment

Development of a personal decontamination outfit and of a protective overgarment for the Services is nearing completion.

First aid and therapy

Artificial respiration and the use of atropine injections and prophylactic pills are of value in military situations.